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Final Technical Report on NASA Grant NAG 5-1803
Far-Infrared Emission, Gas, and Ultraluminous HII Regions in M101

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We have made deconvolved maps of M101 in each of the 4 IRAS bands in collaboration with Nick Weir, using a new maximum-entropy based model for reconstructing distributions with correlated structure on multiple scales. This new deconvolution procedure, developed by Weir (1992, J.Opt.Soc.Am., submitted), is superior to other maximum entropy-based techniques for several reasons. For our purposes, an important advantage is that it has less artifacts and greatly reduced systematic biases compared with the 'HiRes' maps of M101 produced by Aumann, Fowler, and Melnyk (1990, AJ, 99, 1674), thus it is accurate enough to perform aperture photometry. The deconvolved maps have a maximum resolution of $\sim 30''$, sufficient to resolve the brighest HII complexes and much of the spiral structure. The new maps and our comparison of the far-infrared, gas, and optical distributions are being written up in Kenney, Weir & Scoville (1992, in preparation).

The quality of the reconstructed far-infrared maps is good enough for us to carry out most of the analyses outlined in the original proposal. From a ratio of the $60\mu m$ and $100\mu m$ maps, we have found that the ultraluminous HII complexes in the outer galaxy have the hottest dust temperatures with T$\sim$50-60 K, which is twice as hot as most of the disk. Their extraordinary luminosity in the far-infrared is due to a relatively small amount of dust being heated to high temperatures, rather than a large concentration of dust and gas. A map of the dust opacity at $60\mu m$ (τ_{60}) shows good overall agreement with a map of cold gas (HI+H_2), indicating that throughout most of the galaxy only $\sim$20% of the dust is warm enough to be detected by IRAS. The ultraluminous HII regions have a slightly higher ratio of τ_{60}/σ_{gas}, suggesting that near sites of vigorous star formation there is less cold dust hidden from the IRAS view. Away from the ultraluminous HII complexes, the gas-to-warm dust ratio does not seem to depend on whether the interstellar medium is dominated by atomic or molecular gas.

The ultraluminous HII complexes have a high luminosity-to-gas mass ratio, independent of whether the far-infrared or the Hα emission line is used to measure the luminosity, which implies that gas is being converted into high mass stars more rapidly in these complexes compared to other locations in the disk. The Hα to 60 μm ratio is higher in the brightest HII complexes than in the interarm regions, indicating either that older or less massive stars contribute significantly to the heating dust clouds in interarm regions, or that HII regions are leaky enough to allow much of their energy to travel hundreds of parsecs before being absorbed by dust grains.

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